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Indian Standard

CODE OF PRACTICE FOR INSPECTION AND MAINTENANCE OF CROSS DRAINAGE WORKS

(*First Revision*)

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Indian Standard
CODE OF PRACTICE FOR INSPECTION AND MAINTENANCE OF CROSS DRAINAGE WORKS
(First Revision)

Cross Drainage Works Sectional Committee, BDC 61

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Indian Standard

CODE OF PRACTICE FOR INSPECTION AND MAINTENANCE OF CROSS DRAINAGE WORKS

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 31 December 1981, after the draft finalized by the Cross Drainage Works Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Cross drainage works are structures constructed to negotiate a carrier channel over, below or at the same level of a drainage stream or another carrier channel.

0.3 The junctions of cross drainage works with the canal banks are vulnerable and susceptible to erosion during floods. It is essential that these works are inspected periodically and adequately maintained to safeguard them against possible damages or failures. Damages to structures/property and life may occur as a result of failures of such cross drainage works.

0.4 It is necessary that the drawings of works as executed and as amended from time to time are kept up to date and are maintained as permanent record, so as to be available readily for consultation. This information may be exhibited at the sites, wherever needed. It is also necessary that the engineers-in-charge make themselves familiar with the basis of design of the works/structures.

0.5 This standard was first issued in 1974. The revision of the standard has been taken up in the light of the experience gained since then. The salient changes made in this revision are given below:

a) Provisions regarding inspection of cross drainage works have been modified;

b) A new clause on 'damages to cross drainage works and remedial measures' has been added;

c) Maintenance aspects have also been modified, duly categorizing them into 3 groups, namely, before monsoon, during monsoon and post-monsoon; and

d) Appendices A and B regarding proforma for recording details of cross drainage works and proforma for reporting inspection of cross drainage works have been modified.

1. SCOPE

1.1 This code covers general guidelines for inspection and maintenance of cross drainage works. This does not cover cross drainage works of highways and railways.

2. TERMINOLOGY

2.0 For the purpose of this code, the following definitions and those given in IS : 7784 (Part I)-1975* and IS : 4410 (Part XV/Sec 5)-1977† shall apply.

2.1 Berming — The deposition of material on the sides of a drainage channel forming berms and shelves.

2.2 Berm Trimming — Removing or cutting of the overgrowths or overhanging portions of berms and restoring the berms to their prescribed design profile.

NOTE — The need for restoring the berms after trimming is not to be lost sight of.

2.3 Breach — A cut or an opening caused in an embankment by burrowing animals, leakage, piping, slips, settlements, or washouts during rains, flood or in any other manner.

2.4 Caving — The erosion of a bank by the undermining action of water.

2.5 Hydraulic Pressure — Pressure exerted on the lining, membranes or retaining walls etc, by water in/on a hydraulic structure.

2.6 Improvement — Where an experience of damages to a hydraulic structure indicates the need for improvement of the structure, this shall be carried out to safeguard the structure.

2.7 Maintenance — The operations performed for preserving the structures and embankments in efficient operational condition.

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*Code of practice for design of cross drainage works: Part I General features.

†Glossary of terms relating to river valley projects: Part XV Canal structures, Section 5 Cross drainage works.

2.8 Outflanking — The breach in a canal by the side of cross drainage works due to blocking of works or excessive discharge in the drainage stream or due to failure of the banks of a carrier channel.

2.9 Repair — The restoration of damaged portions of embankments, hydraulic structures, etc to their normal shapes, without increasing the capital value.

2.10 Remodelling — Modifying or increasing the scope of an existing structure, such as reshaping the entry conditions, providing transitions, strengthening floors, increasing the carrying capacity to make it safe for the existing or increased flow conditions, etc the cost of which is charged to additions and improvements and charged to capital cost. The cost for such remodelling shall not be borne under maintenance.

2.11 Settlement or Subsidence — Lowering of the top level of a bank or the floor of a canal as a result of voids, compressibility or consolidation of the underlying stratum or the embankment material.

2.12 Sloughing — Sliding of overlying material where the bank or an underlying stratum is saturated.

2.13 Undermining — Erosion or subsidence at the base or under part of the foundations of a hydraulic structure by the action of water or other natural phenomena.

2.14 Washout (Shori) — The washing away of earth from the banks, hydraulic structures, floors and linings caused by burrowing animals, erosive action of water and inadequate drainage of sub-grade, or any other reason leading to partial or complete damage of banks, structures, floors or lining.

3. CATEGORIES OF CROSS DRAINAGE WORKS

3.1 The different categories of cross drainage works are described in IS : 7784 (Part I)-1975*.

4. INSPECTION

4.1 Regular inspections of cross drainage works are necessary every year before the floods to ascertain/examine their state of condition and after the floods to ascertain actual functioning and damage, if any, during the floods. Certain inspections are to be carried out during the canal closure. All inspections shall be directed to the following aspects:

a) To see that the cross drainage and appurtenant works are in good operating conditions and to make them operable if they are not so. To determine after the floods the repairs or remodelling measures required;

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*Code of practice for design of cross drainage works: Part I General features.

b) To see if any leakage from the canal is taking place at vulnerable locations;

c) To investigate for presence of any unusual phenomenon in respect of boils, piping, sweating of bank or saturation of substratum etc or cracks in the structure;

d) To check any changes in the design features in the field, and to restore it to the original design and to redesign the hydraulic structures after the floods, if so warranted;

e) To study the behaviour of pressure relief valves, weepholes, and filters, if any, installed in the floors/retaining walls of cross drainage works;

f) To study the water levels recorded and the quantum of flood discharge passed through the cross drainage work for evaluating its performance. In case of excessive rise of levels, investigations have to be carried out and remedial action taken to improve the conditions, if necessary, also during canal closure. If it is due to blocking of passage, the works may have to be de-watered for inspection; and

g) To study the longitudinal section of drainage to see whether aggradation and degradation are taking place, endangering the safety of the structure.

4.1.1 In addition to the items given in **4.1**, the inspection shall include investigation of the following aspects to guard against damages occurring to the cross drainage work:

a) Investigate if any meandering of the drainage channel in the vicinity of the structure or change of flow pattern has occurred during the previous monsoon period;

b) Investigate whether new streams have been diverted into the main stream for which the work has been constructed, resulting in inadequate capacity of the cross drainage work;

c) Investigate if any obstruction has been created in the drainage higher up or lower down and ascertain if such obstruction has affected the functioning of the cross drainage structure;

d) Investigate whether the tanks on the upstream of the structure are in good condition; and

e) Investigate the construction of bridge or other structures, with less waterway, which may increase the H.F.L. as a result of afflux.

4.2 Cross drainage works shall be inspected periodically, the inspection shall be not less than twice every year, atleast once before monsoon and once immediately after monsoon. In addition, whenever a flood exceeding the design flood or the previously recorded highest flood passes the cross drainage works, the structure shall be inspected to study the effects of the flood and suitable ameliorative measures shall be taken.

4.3 Upstream and downstream floods, loose aprons and filters, if any, of cross drainage works require particular attention during inspection. Any damage or settlement in them shall require special investigation to initiate timely and adequate measures for restoration to avoid further damage during subsequent floods. Likewise, training works such as groynes, guide bunds, spurs, etc shall also receive special attention during inspection regarding their stability and upkeep, so that any damage and/or settlement of pitching and loose apron may not result in shifting the course of the stream and attack the banks of the canal and sides of cross drainage works.

4.4 The bearings and gates, if provided, shall be inspected before and after monsoon to check whether foreign materials are lodged around them and/or the same are rusted. Seals/waterstops provided may be checked to see if they are in tact.

4.5 Faithful record of history of behaviour of structures and damage to important works during monsoons or otherwise and repairs carried out shall be maintained in the log books of damage and repairs for the major structures. Such record shall be made available during inspection by inspecting officers for their remarks.

4.6 An inspection register shall be maintained for all cross drainage works. Its first few pages shall contain the hydraulic and structural design details of the cross drainage works in the pro forma given in Appendix A. A few pages for the inspection reports of the inspecting officers for each year shall be maintained using the pro forma given in Appendix B.

5. DAMAGES TO CROSS DRAINAGE WORKS AND REMEDIAL MEASURES

5.1 Damages to cross drainage works are manifested by the following:

a) Silting and/or berming/choking in the drainage channel;
b) Seepage, piping, scour and/or undermining;
c) Sloughing and/or caving;
d) Uplift and/or upheaval;
e) Structural cracks;

f) Out flanking/over-topping;

g) Sinking and/or differential settlements;

h) Growth of shrubs and other vegetation in the drainage barrels;

j) Meandering of u/s reach and/or change in the drainage course in the vicinity of cross drainage work;

k) Choking of pressure relief valves/filters;

m) Bearings not functioning properly;

n) Malfunctioning of gates; and

p) Leakage through joints, seals and waterstops.

5.2 Remedial measures for the damages to cross drainage works are mentioned below:

a) Silting is a common feature observed in cross drainage works. Silting takes place in the bed of the approach channel, drainage vents and exit channel, resulting in reduction of effective area for passage of water causing heading up of water to levels higher than designed, thereby over-topping the cross drainage works and canal banks. A meandering drainage course is likely to deposit silt in a disproportionate manner in the drainage course. Regarding/desilting of the bed and training of the drainage course can be considered. If choking due to debris has taken place, this shall be immediately cleared.

b) Undermining of the structures by deep scours during flood is one of the serious dangers to be guarded against. The actual condition cannot be inspected during floods as the damage done cannot be seen or nothing comes to light as the scour pit gets filled up during receding floods. Where excessive scours are suspected due to the deposit of the material in the scour pit, the depth of the scours can be ascertained by the material deposited. Suitable measures for the foundations may be made as needed.

   Piping may also be a cause for undermining of the structure. The following steps shall be taken to prevent scour taking place:

   i) The waterway of the cross drainage works shall be kept free from any obstruction by regular clearance of sediment deposits, debris, trees, stumps of wood, etc found therein;

   ii) To replenish concrete blocks/stone apron provided in front of upstream and downstream cutoffs as a regular maintenance measure;

iii) Need to provide deeper cutoff or increasing length of existing floor may have to be examined and adequate remedial measures taken in case piping has set in, as evidenced by cavities detected under floors; and

iv) To prevent such cavities in the floor, provision of compacted filter material to form subgrade shall be made. Where cavities have been noticed, the floor shall be removed above it, the cavities filled with compacted filter material and the floor repaired in addition to taking up the measures mentioned in item (iii) above.

c) Sloughing and/or caving of the guide banks of approach and tail channel and canal banks at the junctions of cross drainage works are to be prevented. Sloughing of guide banks may obstruct the water passage, causing heading up of water with consequential over-topping of structure or undermining and scour downstream. Adequate, timely steps shall be taken after inspection to prevent sloughing or caving of banks, if anticipated.

d) Malfunctioning of the pressure relief arrangements/weepholes/ filters would indicate upheaval and/or bulging. The relief arrangements provided may be checked and adequate relief arrangements may be provided.

e) Structural cracks may develop as a result of excessive stresses caused due to overloading, inadequate design, settlement of foundation, substandard construction or other extraneous factors not anticipated and provided for in the design. Timely action shall be taken to prevent aggravation of the cracks and remedial measures to repair them.

f) Out flanking or over topping may occur as a result of channel embayment, berming, silting and/or inadequate freeboard, piping or erosion at the interface between the structure and the embankment. Remedial measures such as adequate freeboard, training measures, increase of rear berm, provision of filters, zoning of materials in banks, etc may be adopted.

g) Sinking or differential settlements of the abutments/piers may occur due to non-uniform foundation conditions. This may lead to tilting of abutments/piers and consequent disturbance in the alignment/grade in longitudinal direction. Tilting or differential settlement can also lead to reduction in the clearance between slabs/beams at supports, resulting in structural damages, if not provided for adequately in the design. Timely action in ensuring the behaviour of the structure in this regard shall be taken.

h) The barrel portion, the exit and entry shall be rendered free of any growth of shrubs and other vegetation to avoid obstruction to the drain flow. Weeds may be deposited in the course during floods and their growth shall restrict the waterway. Growth of vegetation on the structure may create cracks and may also affect the discharging capacity of the structure. All such vegetation shall be cleared periodically.

j) A meandering water course in the vicinity of the cross drainage work may result in embayment or endanger the downstream protection work. Suitable training measures may be adopted to define the drainage course to its original regime.

k) Displacement of the bed of canal, sides of banks and retaining walls may indicate inadequate pressure relief or choking of relief valves or filters. Replacement by suitable pressure relief measures shall be immediately undertaken.

m) Damage to the bearings by floating materials, either through choking or by direct dashing, would necessitate the clearance of material or replacement of bearings. Rust, if any, shall be cleaned and bearings kept well lubricated.

n) Damages to hoists, gate leaves and embedded parts shall be immediately attended to.

p) All leakages through gate seals shall be immediately attended to by replacement. In case of leaks through joints and waterstops, suitable fillers may be provided to stop the leakage.

6. MAINTENANCE

6.1 Before Monsoon

6.1.1 The approach and exit channels in the vicinity of cross drainage works shall be cleared of silt, debris, stumps, branches of trees, etc before the onset of monsoon or the reopening of the channel after a closure, to keep the work free from obstructions.

6.1.2 Any crack and hole in upstream and downstream floors of the cross drainage works shall be duly repaired well before the monsoon sets in. Any potholes or open joints in the masonry/concrete in the floor or side walls shall be properly repaired. Any deviation from the original formations on the bed and sides is to be noticed.

6.1.3 The drainage or weepholes and pressure release valves in abutments, wings, etc shall be cleaned of all extraneous matter to prevent building up of hydrostatic pressure, in excess of the designed provision.

6.1.4 It shall be ensured that the water seals or the asphalt joints are in tact. Leakage through water seals whether in canal through, or in the drainage vents, shall be corrected as far as possible by the use of appropriate filler material.

6.1.5 Any foreign material deposited on the bearings shall be removed. The bearings shall be cleaned and well lubricated and shall be brought to perfect working condition.

6.1.6 Arrangements for the surface drainage on the top of the bank may be provided and maintained to enable surface water to drain without damaging the banks.

6.1.7 Concrete blocks/stone apron provided in front of upstream and downstream cutoffs may be replenished as a regular maintenance measure.

6.1.8 In case of indication of piping, need to provide deeper cutoff or increased length of existing floor or provision of loading berms and filters may have to be ascertained and adequate remedial measure taken in case piping has set in.

6.2 During Monsoon

6.2.1 During monsoon, in major cross drainage works, a vigilant watch is to be kept of the increase in flood discharge and adequate precautions may be taken to ensure that the flood is discharged effectively. Adequate readings are to be kept during the floods at appropriate intervals of both the rise in level and the discharge to enable an accurate stage discharge curve to be arrived at. Return flows and eddies near cross drainage work abutments may have to be carefully watched to ensure that no erosion takes place.

6.2.2 All fallen out, displaced or disturbed pitching of guide banks or sunken portions of aprons shall be timely repaired. It shall be ensured that the pitching is in tact up to the freeboard level.

6.3 Post-Monsoon

6.3.1 If any caving, rut or gully is observed in the canal banks or at junctions, it shall be treated with suitable selected soil after removing all loose material.

6.3.2 The settlement of shrinkage cracks, if any, in masonry/concrete shall be properly treated with cement mortar of 1 : 3 mix, or a richer mix if required. Peeling off of mortar at the joint shall also be made good with cement mortar (1 : 3) and smooth pointed. Recurring cracks or cracks wider than 25 mm call for special investigation into possible causes and suitable corrective actions for repair. Telltales, where necessary, shall be used in such cases. In case of excessive settlement of foundations, further settlement shall be prevented by 'under pinning' of foundations.

6.3.3 If hair cracks are noticed in the reinforced concrete slab or beams, they shall be carefully pressure-grouted with neat cement grout after thorough investigation of the cause. If wider cracks are noticed, they shall be grouted with mortar grout of rich mix of cement and sand.

If peeling off of concrete is noticed, exposing reinforcement, the damage may be repaired by Guniting or Shot-creting with B.R.C. fabric, after chiselling out the loose portions of concrete or mortar around the reinforcement and pre-wetting the surface with cement slurry. To prevent leakage, appropriate sealant compound may be provided at all edges.

6.3.4 The gauges provided shall be repainted periodically to make them legible. It would be preferable if enamel gauge plates are provided, as markings done on these plates do not fade out for a long time. The gauges shall be checked for correctness.

6.3.5 Any damage to the bed and sides is to be recorded on the appropriate register and arrangements made to prepare it.

APPENDIX A

(*Clause* 4.6)

PRO FORMA FOR RECORDING DETAILS OF CROSS DRAINAGE WORKS

District:

Village:

Name of the carrier channel:

Designation of C.D. Work:

A-1. GENERAL FEATURES

a) Type,
b) Location (chainage in km) of the canal,
c) Angle of crossing,
d) Date of starting construction,
e) Date of completion,
f) Date of commissioning, and
g) Cost.

A-2. HYDRAULIC FEATURES

A-2.1 Hydraulic Features of the Drainage

a) Name,
b) Name of the minor basin,
c) Name of the major basin,
d) Position and extent of the minor basin,
e) Average rainfall registered at the stations within a minor basin,
f) Maximum recorded rainfall in the minor basin (in 24 hours),
g) Catchment area above the cross drainage works,
h) Bed level of the stream,
j) Normal flood discharge,
k) Maximum observed flood discharge and date of occurrence and corresponding H.F.L.,
m) Surface velocity (mean velocity for major C.D. works) at H.F.L.,
n) Bed slope/surface slope,
p) Width of the stream,
q) Depth of flow at normal flood,
r) Cross sections at crossing u/s and d/s at a distance of 50 to 500 m from axis,
s) Bed material, detailed gradation data and Lacey's silt factor, and coefficient of rugosity adopted for design, based on field conditions,
t) L-section of the drainage showing number of tank on both and d/s with their capacities, and
u) Existing structures on the drainage and their location with reference to the C.D. work and their hydraulic particulars.

A-2.2 Hydraulic Features of Canal

a) Name of canal,
b) Discharge,
c) Depth of flow,
d) Bed width,
e) Bed level at the crossing,
f) Velocity,
g) Freeboard,

h) Full supply level on u/s and d/s of the structure to measure the loss of head,

j) Top levels of bank,

k) Bed slope,

m) Side slope,

n) Lacey's silt factor or Manning's 'N',

p) Type and details of pitching/lining,

q) Details of under drainage arrangements provided behind pitching/lining,

r) Depth of flow designed/observed u/s and d/s of the cross drainage work,

s) Bed fall, and

t) Bed material.

A-2.3 Hydraulic Features of Cross Drainage Work

a) Designed flood discharge and corresponding H.F.L. at u/s, d/s and at centre,

b) Number and size of openings of waterway,

c) Velocity through cross drainage works,

d) Depth of flow through the cross drainage works,

e) Slop provided through the cross drainage works,

f) L-section and cross-section of cross drainage works,

g) Type of energy dissipation arrangement provided with details,

h) Heading up or afflux allowed,

j) Observed highest flood level at u/s and d/s of the structure, and

k) Scours provided in the design.

A-2.4 Hydraulic Features of Canal Trough/Barrel Portion

a) Length of trough/barrel portion;

b) Width of trough/barrel portion;

c) Depth of flow in trough/barrel portion;

d) Velocity;

e) Bed level;

f) Bed slope;

g) Details of energy dissipation arrangement in the canal provided at the crossing for small discharges;

h) Details of hump, if any, provided at the crossing;

j) Design heading up or afflux;
k) F.S. levels at u/s and d/s of the structure to measure the loss of head;
m) Details of transitions, if any, upstream and downstream; and
n) Side slop, if any.

A-3. STRUCTURAL FEATURES

a) Nature of strata on which the structure is founded (data of bore logs);
b) Depth of foundation below the floor level;
c) Details of foundation structure;
d) Particulars of sub-structure;
e) Type and particulars of wings and returns on the drainage;
f) Height of sub-structure;
g) Particulars of wings and returns on the canal;
h) Details of drainage floor and end cutoffs;
j) Details of canal floor and end cutoffs;
k) Type of superstructure;
m) Details of weepholes/pressure release valve arrangements provided in the floor, abutment and wings;
n) Details of uplift pressure observation arrangement provided;
p) Details of loose stone apron arrangement provided;
q) Details of groynes, guide banks, spurs, etc provided to train the stream; and
r) Value of seismic accleration, if adopted for design.

APPENDIX B

(*Clause* 4.6)

PRO FORMA FOR REPORTING INSPECTION OF CROSS DRAINAGE WORKS

a) Name of the carrier channel;
b) Name of the stream;
c) Type of cross drainage work;
d) Location (chainage in km) of the canal;
e) Catchment area of stream;

f) No. and size of openings of waterway; and

g) Whether the repairs or remedial measures suggested during the last inspection have been carried out ? If so, whether the same troubles are observed during the present inspection also ? If so, what are the probable reasons for such recurrence ?'

Design discharge............	cumecs	Design levels	Upstream Downstream
Maximum discharge of year	cumecs	Observed levels	Upstream Downstream

Date of compliance of last inspection remarks . ...

Date of inspection...............

Date of last inspection.........

Sl No.	*Item*	*Condition*	*Nature of Repairs Required*	*Approx Cost*	*Remedial Measures Suggested to Rectify the Defect, if Any*	*Steps Taken to Remedy Defects, if Any*	*Remarks*
1.	Waterway, drainage vents and approach and exit channel						
2.	Foundations						
3.	Substructure						
4.	Superstructure						
5.	Canal banks and guide banks						
6.	Protective works (u/s and d/s of the drainage work)						
7.	General conditions regarding alignment, grades in long and cross direction, bearing and supports and clearance between structural members						
8.	Other allied items of cross drainage work						

Signature..................................
Name & Designation............................
of Inspecting Officer..........................

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Plot No. A-9, House No. 561/63, Sindhu Nagar, Kanpur Road, LUCKNOW 226005	5 55 07
Patliputra Industrial Estate, PATNA 800013	6 23 05
District Industries Centre Complex, Bagh-e-Ali Maidan, SRINAGAR 190011	—
T. C. No. 14/1421, University P. O., Palayam, THIRUVANANTHAPURAM 695034	6 21 04

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